3.6 APPENDICES

APPENDIX A Status and Trend of bull trout in Montana

The following status and trend information was excerpted from the USDI (2005a) Bull Trout Conservation Status Assessment, Bull Trout Core Area Templates (USDI 2005b) and the 2008 update to the core area templates (Wade Fredenberg, US Fish and Wildlife Service; in litt.); see those documents for references therein. The information is summarized by bull trout core area population, and indicated by the 4th, 5th, and/or 6th level Hydrologic Unit Code (HUC) for western Montana. There is an emphasis on the low- to mid-elevation streams that occur primarily on private farm and ranch lands; not included are several upper elevation 5th HUC's that occur entirely or primarily on Federal lands.

Saint Mary Basin

Several core areas have been identified in the St. Mary River and Belly-River basins in Montana and are summarized. The Belly-River basin, located entirely within Glacier National Park, is not included. The status and trend of bull trout in these subunits, within this recovery unit were considered "unknown" based on information available at the time of listing. Given the significant effort to obtain information for the core areas in the St. Mary R basin since 1998, each core area outside of, or straddling the park boundary is described separately.

Lee Creek – 100100020401, 100100020402

There appears to be both a fluvial migratory component to this population, and less well documented but potentially present are resident fish; a possible adfluvial component may occur downstream in Alberta, Canada. Two (Lee and Jule Creeks) or more local populations are present. There is no data available to indicate fish abundance prior to construction of major irrigation projects beginning in 1906. Available information is insufficient to determine the abundance or trend of adult bull trout in this core area.

No recaptures of previously tagged fish from other drainages have occurred in Lee Cr, nor of fish emigrating to other waters. Adult fish observed in US waters are suspected migrants completing spawning runs from downstream portions of Lee Creek or St. Mary Reservoir in Alberta. This core area represents a special case, due to the international border. The headwaters are in Montana, with much of the core area downstream in Alberta.

A few bull trout are present in the lowermost reaches of Middle Fork Lee Cr where stream habitat is substantially impaired by sediment, and a fish passage barrier is present at a major road culvert. While results of fish movement studies found no evidence that fish from Lee Cr intermingle with those from the St. Mary R core area, such movement is possible due to connectivity with the St. Mary R just upstream of St. Mary Reservoir in Alberta. Overall, not much is known about movement patterns of bull trout in Lee Creek outside the Montana headwaters. However, movement patterns were often complex, with both upstream and downstream seasonal migration detected; none of the fish tracked in Montana moved downstream to St. Mary Reservoir or up Lee Cr.

Watersheds in this core area exhibit a high degree of natural instability, with tremendous bedload movement and very active channel migration. It is a constant challenge to manage roads,

bridges, and other infrastructure in proximity to floodplains within this core area. In addition, there is an active timber management program on the Blackfeet Reservation. A new 15-year timber management plan (2008-2022) was adopted by US Bureau of Indian Affairs in 2008 and it will incorporate standards similar to INFISH along streams containing bull trout. Timber harvest is scheduled for 2011 to 2021.

Genetic sampling for this core area is complete (no results available) and will be useful in characterizing the relationships amongst bull trout core populations in the St. Mary R drainage. Analyses will include the evaluation of genetic structuring amongst populations, evidence of gene flow and genetic diversity, and the relatedness of Lee Cr and Belly River populations, to populations elsewhere in the US portions of the St. Mary R drainage. Analysis of bull trout populations in the connected core areas in the Flathead Basin headwaters west of Glacier National Park showed a high degree of genetic differentiation among local populations. Not surprisingly, results were consistent with observed patterns of barrier presence and absence; genetic divergence was greater in lakes not isolated above barriers (i.e., migration between local populations) and lowest in lakes upstream of barriers. Similar results may be anticipated in the closely linked core areas in the St. Mary R drainage. In addition, examination of phenotypic characteristics of thousands of fish indicated little introgression with brook trout in these core areas.

A water rights compact between the State of Montana and the Blackfeet Nation has been approved by the Montana Reserved Water Rights Compact Commission. The Blackfeet Tribal Business council has authorized the compact to be taken forward to the US Congress, the 2009 session of the Montana legislature, and ultimately the Blackfeet Tribal members for final approval. In part, the compact allocates “available St. Mary R Water”, which is further defined in the compact, subject to the Boundary Waters Treaty and the existing Milk River Project water right. Among other things, the compact quantifies the Tribal water right as 50,000 acre feet per year from the St. Mary R with a priority date of October 17, 1855 and also establishes that the Blackfeet Nation is entitled to develop storage within the reservation to effectuate that water right, so long as existing uses of the Milk River Project are not adversely impacted. The settlement also gives the Tribe the right to “all natural flow available to the US under the Boundary Waters Treaty and all ground water in Lee Cr within the reservation, with the exception of those waters subject to State Water Rights.” This compact settlement clarifies much of the existing status of water rights in the basin, but still leaves unresolved significant issues regarding instream flow for fish and allocation of waters of the St. Mary R under the Boundary Waters Treaty.

The Blackfeet Nation Bull Trout Management Plan was finalized in November, 2007 and awaits adoption by the Blackfeet Tribal Business Council. This document evolved from negotiation between the Tribe and the FWS over the status of proposed bull trout critical habitat on the Blackfeet Reservation. In exchange for foregoing the designation of critical habitat in Tribal waters, the Tribe agreed to pursue management actions, including but not limited to funding a fisheries biologist (now accomplished), reducing certain habitat impacts, resolving entrainment and fish passage issues at the St. Mary Diversion Dam, eliminating road culvert passage barriers, improving livestock grazing and forestry practices, reducing impacts of anglers and commercial fisheries on bull trout, and instituting annual monitoring among others. The document is not regulatory, but certain aspects involving enforcement are incorporated in the Management Plan.

The Blackfeet Reservation is closed to all angler harvest of bull trout, except where they are stocked in closed basin waters. Extensive electrofishing and trapping has occurred in the St. Mary R and its tributaries for a nearly 10-year research effort on movements of bull trout in the system. While not believed to be excessive, the capture and handling of fish has no doubt resulted in some bull trout mortality, which should be reduced or eliminated as needed, for this information has largely been satisfied.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Other** – Most of the Lee Creek Core Area is in Canada and threat remediation and recovery is heavily dependent on the province of Alberta and the Canadian Government.
- **#2 Fish passage issues** (artificial barriers to migration).

Much of the spawning and rearing habitat in the Lee Cr core area is in Montana and portions have been degraded, but other areas in Glacier National Park remain intact. There is considerable uncertainty about the habitat quality and viability of Lee Cr migratory fish, as well as the status of St. Mary Reservoir in Alberta which provides marginal habitat for bull trout in years of high irrigation water demand. Since this core area appears to be almost totally dependent on a small number of spawning and rearing reaches in Lee Cr and Jule Cr, any perturbations would likely impact the entire core area population. These threats impact spawning and rearing habitat throughout the core area outside of Glacier National Park, and likely affect downstream foraging, migration, and over-wintering (FMO) habitat of any adfluvial fish that may be present.

Water temperatures during mid-summer in Lee Cr may approach or exceed the threshold for bull trout, primarily due to reduced stream flows associated with water withdrawals. Elevated water temperatures due to climate change may be particularly problematic in St. Mary Reservoir which lacks the depth to provide cold-water refuge. There is considerable ground water influence in most of the headwater tributaries buffering those streams from the increasing summer water temperatures.

Saint Mary – 100100020301, 100100020302, 100100020303, 100100020304, 100100020305
There is a strong migratory component to this core area population, which is primarily fluvial but may include some adfluvial fish. This fluvial dominance occurs despite the availability of large deep lakes that could support an adfluvial population, and may be a result of habitat partitioning with native lake trout present in the St. Mary Lakes. Resident fish are less well documented but potentially present in some tributaries. Downstream portions of the core area (including much of the migratory and overwintering habitat) occur mostly in Alberta, Canada.

Four local populations are known in the St. Mary R core area: Divide, Boulder, Kennedy, and Otatso Creeks. Juvenile migratory bull trout typically leave these natal tributaries as age-II age-III fish, inhabit the mainstem St. Mary R or lakes as subadults (age-III and older) and reach maturity as age-V and older fish; spawning begins in late September. The presence of smaller bodied age-IV fish in downstream portions of Otatso Creek, as well as Lee, Kennedy, and Canyon Creeks indicates a resident component to the bull trout populations in this core area.

Annual redd counts since 1997 in index reaches of the two primary spawning streams (Boulder and Kennedy Creeks) indicate adult bull trout abundance is stable, with about 40-50 redds tallied annually. However, the local population in Divide Creek appears near extirpation. Ultimately, the migratory component of bull trout is dependent on FMO habitat conditions, which are not well described, downstream in Alberta. Based on these and other monitoring data an estimated minimum 250 adult bull trout are present in the St. Mary R core area. An estimate of adult fish (>300 mm) in the population using tagging and recapture-event data suggest more than 500 adults in the spawning population. No abundance data are available prior to construction of major irrigation projects beginning in 1906.

Genetic analysis confirmed isolation of bull trout in the upper Otatso Creek (Slide Lakes) watershed from the St. Mary R core area. Similar findings are expected, though not yet available for Cracker Lake, Red Eagle Lake, and Lee Creek (in Glacier NP). Extremely low numbers of adult bull trout and sporadic recruitment of juveniles from Divide Creek indicate that local population is well below thresholds for viability (e.g., <50 spawning adults).

A study of ranging behavior amongst six tributary systems (Divide, Boulder, Kennedy, Otatso, Lee, and Canyon Creeks) in the St. Mary R core area showed 82% of bull trout were recaptured in the same stream where marked. The remaining 18% of fish were recaptured in different streams. Movements generally occurred both up and downstream within the four local populations (Divide, Boulder, Kennedy, and Otatso Creeks); no ranging movements were observed in Slide Lake, Lee Cr or Cracker Lake (Canyon Cr), confirming each to be separate core areas. Most of the documented movement was between Kennedy and middle and lower Otatso Creeks; Otatso Creek is tributary to lower Kennedy Creek, with Slide Lake near its headwaters. A single adult bull trout first tagged in 1998 in Kennedy Creek, was recaptured twice (2000 and 2002) in Boulder Creek, a third time in an entrainment study in the St. Mary canal (2002), and yet again in Boulder Creek in 2004. Such complex ranging behavior is may be a consequence of habitat fragmentation caused by the St. Mary canal diversion structure.

In addition, sporadic observations of juvenile bull trout (probably representing cases of vagrancy) have been recorded in the lower-most reaches of Wild Creek, a tributary of the St. Mary R upstream of Lower Saint Mary Lake, and in Rose Cr, a direct tributary of Saint Mary Lake.

Radio telemetry was used to determine large-scale, seasonal movements and wintering areas of adult bull trout in the St. Mary R drainage, Montana and Alberta. The fish proved to be highly mobile (movements up to 83 km) throughout the entire accessible mainstem of the St. Mary R between St. Mary Reservoir (Alberta) and Lower Saint Mary Lake (Montana), and in several major tributaries. May-July and October-November were found to be the periods of greatest pre- and post-spawning movement, respectively; both upstream and downstream seasonal migration was detected.

A major obstacle to movement was documented at the St. Mary Diversion Dam, downstream of Lower St. Mary Lake. The diversion is at least a partial barrier between April and September, when placement of stop boards creates a dam approximately 6 ft in height. Some bull trout have passed the diversion dam upstream, although passage timing was not precisely determined. Ironically, blocking this movement may preclude some fish from being entrained in the St. Mary

canal, which heads immediately upstream of the diversion and often takes over half the stream flow. The diversion dam obstacle is likely of greatest significance to local populations in Boulder Creek or Divide Creek. Adults from those spawning and rearing streams over-winter downstream of the diversion, and may be precluded from returning to natal spawning habitat.

In addition to the St. Mary Diversion Dam, diversions on the St. Mary R located downstream in Alberta are screened and have some type of passage incorporated, but effectiveness is not monitored. The major spawning tributaries (Boulder, Kennedy, and Otatso Creeks) have seasonally dewatered reaches as a result of natural conditions. The upwelling zones downstream of the seasonally dewatered reaches are the primary bull trout spawning habitat.

The fate of bull trout in this core area is directly tied to successful resolution of water allocation and distribution issues in the St. Mary portion of the Milk River Irrigation Project in the US, and other projects of a similar nature in Canada. To date, most of the focus has been on operations of the St. Mary Canal through informal consultation with the US Bureau of Reclamation.

With the exception of Divide Creek and portions of the Lee Creek headwaters, human-caused impacts present some concern. Most tributary habitat is functioning appropriately given the harsh geomorphic landscape that result in landslides, natural dewatering, and patchy habitat caused by high bedload movement in this watershed. The importance of the mainstem St. Mary R as FMO habitat for bull trout in this interconnected system cannot be overstated.

Bull trout in the St. Mary R drainage are negatively affected by operation of water-storage and delivery systems associated with the Milk River Irrigation Project. Recommendations include (1) year-around passage at the diversion, (2) minimum instream winter flow releases from Sherburne Dam, (3) screening of the St. Mary canal to prevent entrainment, and (4) assessment and remediation, if necessary, of instream flow depletion in the St. Mary R. The US Bureau of Reclamation is currently considering options to resolve these issues.

Watersheds in this core area exhibit a high degree of natural instability, with tremendous bedload movement and very active channel migration. It is a constant challenge to manage roads, bridges, and other infrastructure in proximity to floodplains within the core area. In addition, there is an active timber management program on the Blackfeet Reservation. See the Lee Cr core area discussion regarding the timber harvest.

Limited genetic analysis using microsatellite loci from bull trout found consistent differences between bull trout from east (St. Mary R drainage) and west (Flathead R drainage) of the continental divide. In the St. Mary R drainage there was relatively low genetic differentiation among sites, indicating migration among populations. Additional genetic samples (no results available) will be useful in further characterizing the relationships amongst bull trout core populations in the St. Mary R drainage on the east side of Glacier NP. See the genetic summary for Lee Cr core area.

Non-native fish, especially brook trout, do not appear to be an impending threat to bull trout in this core area. However, brook trout were present in electrofishing samples in Divide, Boulder, and Kennedy Creeks, where they comprised up to 21% of the species composition. Brook trout constituted a small proportion of the tributary fish communities and there was no evidence brook

trout have displaced bull trout, or that hybridization was an emerging threat in the St. Mary R core area. However, there is anecdotal evidence that the brook trout population, particularly in Kennedy Creek, could be increasing; continued monitoring is warranted. In addition, some populations in this core area were sampled for incorporation into the US Fish and Wild Service National Wild Fish Health Survey. No pathogens of concern were detected. Samples of fish tissue were collected in 2008 from St. Mary Lake to test for elevated mercury contamination; no results are available.

In 2006, the Red Eagle fire burned more than 34,000 acres in Glacier NP and the Blackfeet Reservation. The fire was centered in the Red Eagle and Divide Creek drainages. October, 2006 electrofishing surveys captured 86 *Oncorhynchus spp.* but no bull trout in the Divide Creek drainage.

In recent years, livestock encroachment into Glacier NP from Blackfeet grazing allotments has damaged riparian habitat along important spawning and rearing reaches of Kennedy and (to a lesser extent) Boulder and Otatso Creeks. While direct evidence of bull trout loss has not been documented, there is increasing concern of redd trampling, which has been demonstrated to result egg mortality through physical injury. The issue is part of a long-standing dispute over the park boundary that (in the view of some) could be resolved by drift fencing along the stream corridors. See the Lee Cr core area discussions regarding the Western Airborne Contaminants Assessment Project (WACAP), the water rights compact between the State of Montana and the Blackfeet Nation, and the Blackfeet Nation Bull Trout Management Plan.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1a Fish passage issues** (artificial barriers to migration)
- **#1b Entrainment** (hydropower and diversions)
- **#1c Dewatering**.

These three issues, all associated with the St. Mary Diversion Dam and Milk River Irrigation Project, are interrelated and have been identified as the main threats to bull trout in the core area (dewatering, entrainment, fish passage, thermal conditions). There is additional concern, because of disputes over water allocation in the basin and the potential to increase the timing or amount of trans-basin diversions to the Milk River. The International Joint Commission has appointed an International Task Force to examine the history and appropriate use of water allocations under its' 1921 Allocation Order. Pending resolution of those issues, magnitude and imminence of threats may change, either positively or negatively. Secondary threats include the effects of illegal angling, introduced brook trout populations, and livestock grazing along spawning and rearing streams.

At this time much of the spawning and rearing habitat is in Glacier NP and remains productive, with the exception of Divide Cr. If passage, entrainment, and dewatering issues are resolved, it is likely that the bull trout population in this core area will achieve recovery within a few generations. Entrainment and fish passage primarily impact the local populations upstream of the diversion (i.e., Boulder Cr and Divide Cr). Local populations in Kennedy, Otatso, and Lee Creeks are impacted by low flows and FMO habitat issues downstream in Alberta, but likely not by the St. Mary Diversion Dam itself.

Water temperatures in midsummer in the St. Mary R are a concern, primarily due to reduced stream flows and elevated surface water temperature in the Sherburne Reservoir and Lower St. Mary Lake sources. Elevated water temperatures due to climate change may be particularly problematic if fish were concentrated at the diversion and being stressed by anglers. There is considerable ground water influence in most of the tributaries, so water temperatures in those streams are relatively insulated from increasing summer temperatures. A USGS study is being initiated that will assess, in part, the impacts of climate change on native fish in Glacier NP.

Kootenai River Basin

Four core areas have been identified in the Kootenai River basin in Montana: Kootenai River, Lake Koocanusa, Bull Lake, and Sophie Lake. The status and trend of bull trout in this recovery sub-unit were considered "unknown" based on information available at the time of listing. Given the significant effort to obtain information for these core areas since 1998, the areas are described separately. Bull trout were not historically present in the Yaak River subbasin (17010103) upstream of Yaak Falls.

Kootenai River – portions of 17010101, 17010102

The Kootenai R core area was isolated from the upper Kootenai River watershed by the construction of Libby Dam in 1972. There is a strong migratory population in the Kootenai R between Kootenai Falls and Libby Dam. Bull trout have been documented migrating upstream over Kootenai Falls. Less well documented but also present is a weak adfluvial population below the falls that originates from Kootenay Lake, downstream in British Columbia.

Six local populations have been identified in the Kootenai R core area, Quartz, O'Brien, Pipe, Bear (Libby), West Fisher and Callahan Creeks. Monitoring indicates the core area population is declining, with up to 1,000 adult fish. However, interpretation is difficult due to un-quantified immigration of fish from the upstream core area (Lake Koocanusa), abundant brook trout, and bull trout – brook trout hybrids in most of the local populations. A resident population of bull trout in the upper reaches of Libby Creek is isolated by a barrier falls.

Recent genetic surveys have confirmed that population fragmentation is not significant in the Kootenai R core area. Levels of genetic diversity observed (within population) were similar to that seen in the nearby Lake Pend Oreille and Clark Fork systems. The lowest amount of genetic diversity was observed in Libby Creek, and is attributed to the long-term isolation of this population. Libby Creek bull trout were somewhat genetically divergent (between population) from other populations sampled both upstream and downstream of Kootenai Falls and Libby Dam, though not as divergent as those from the Bull Lake core area (Keeler Creek). Populations upstream of Libby Dam (Lake Koocanusa core area) clustered separately from those downstream of the dam (Kootenai River core area), indicating a high degree of genetic variation among bull trout populations within the Kootenai River basin. The data also supported the hypothesis that there is restricted gene flow, but some level of connectivity, between populations above and below Kootenai Falls as radio telemetry studies had indicated.

The Kootenai R downstream of Libby Dam is a heavily regulated river. Habitat impacts from variable flows result from power generation needs, flow requirements for endangered Kootenai River white sturgeon, and downstream flows required for salmon and steelhead smolts to pass through several dams on the Columbia R; additional flow related issues include water quality

(gas super-saturation), downstream reservoir level maintenance, and river recreation. The combined effects lead to erratic and often unpredictable water flows. An attempt is made to balance these varied concerns, but impacts of flow regulation on bull trout are not well documented. Recent physical habitat and fish passage improvements generally offset negative impacts associated with expansion of Montanore Mine, and increased suction dredge activity in the Libby Creek watershed. Legacy effects of timber management and mining leads to an overall trend in habitat condition considered stable to slightly improving.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Introduced species** – brook trout, brown trout, and possibly lake trout
- **#2 Water Quality Impairment –** flow depletion and water temperature in tributaries
- **#3 Forest management practices and forest roads**.

Bull trout abundance is below historical levels in this core area, due largely to dramatic ecological changes and fragmentation from the upper watershed following construction of Libby Dam. Because this core area is now functioning as a separate population, some of the threats may have greater magnitude and imminence, and the fate of main stem habitat is strongly tied to Libby Dam operations. Despite being a relatively large core area, bull trout persistence depends upon only six spawning and rearing streams. The effectiveness of the Plum Creek Native Fish Habitat Conservation Plan (HCP) in protecting and restoring bull trout in the heavily degraded Fisher River drainage is an important element of recovery for this core area. Fragmentation has been less of a concern since it has been established that Kootenai Falls is not a complete barrier to upstream migration by bull trout, as well as entrainment of adult bull trout through Libby Dam.

Bull trout hybridization with brook trout has seriously impacted four of the six local populations. These impacts may be manifesting rapidly as reflected by recent sharp declines of juvenile bull trout in the spawning and rearing habitat. However, the observed declines may be related to the additional threats posed by dewatering in tributaries and increasing summer water temperature. Headwater bull trout streams in this region are typically ground water-influenced, but climate change is expected to have a large impact, due to the low elevation and precipitation patterns that are conducive to frequent rain-on-snow events. The greater relative stability of juvenile bull trout numbers in Quartz Creek and Libby Creek, and lack of apparent influence by brook trout indicate that these problems may be tributary-specific. This may preclude a complete collapse of all spawning and rearing populations in the near future. Unfortunately, recent sampling suggests the threat from introduced species (i.e., combined brook trout, brown trout, and lake trout) is growing.

Lake Koocanusa – 17010101

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area, though some local populations in the upper portions of the watershed (British Columbia) may be primarily fluvial.

Libby Dam, completed in 1972, isolates Lake Koocanusa and the upper portions of the Kootenai River drainage, mostly in British Columbia, from its' former connectivity with Kootenay Lake downstream. An extensive redd monitoring program indicates bull trout exhibited a strong and

steady increase over the past 10-15 years, although most of the spawning and rearing occurs in Canada. Two of approximately 12 local populations, Grave Creek and the headwaters of the Wigwam R, spawn and rear in the US. Monitoring indicates an adult bull trout population exceeding 10,000 fish in the Lake Koocanusa core area.

While Lake Koocanusa is a relatively new reservoir, there was no monitoring of natural carrying capacity prior to listing bull trout in 1998. Prior to dam construction, the river likely provided foraging, migratory, and over-wintering habitat (FMO), with upstream spawning and rearing habitat for the Kootenai River and Kootenay Lake core areas downstream. Available evidence indicates that the present bull trout population occupying Lake Koocanusa is many times the natural capacity that existed in this system prior to dam construction. Also, the robust adult population was the basis for reestablishing an experimental bull trout sport fishery in the reservoir; the fishery has been permitted under an ESA Section 10(a)1(A) research permit since 2004. This core area exhibits the strongest record of an increasing trend that exists anywhere across the entire US range of the species.

Habitat connectivity in this core area is good, although impassable dams or diversions exist on spawning tributaries in Canada (e.g., Elk River, Bull River). Nonetheless, the expanded FMO habitat created by a large reservoir (Lake Koocanusa), with abundant forage (kokanee) and high quality upstream spawning and rearing habitat has created an unusually productive environment.

A large watershed restoration project was completed through a cooperative public/private partnership on Grave Creek in the US. The project largely focused on improving fish passage and reducing bull trout entrainment at the Glen Lake Irrigation District (GLID) diversion in lower Graves Cr, and restoring stream channel and streambank integrity downstream of the diversion. Bull trout entrained in the diversion are essentially lost to the core area in an off-basin reservoir (Glen Lake). Problems with the GLID diversion necessitated partial reconstruction of the diversion structure and bypass channel in 2008, and efforts to improve habitat in lower Grave Creek and further stabilize the channel continue. A potential new diversion (rebuilding an historical structure) is a new threat that could further deplete in-stream flow in Grave Creek.

Several projects to survey and document habitat conditions in the Canadian portions of the watershed have been initiated, and the Kootenai River Network, a non-profit watershed group, formed to facilitate stewardship projects throughout the basin. Potential coal field development and expanded oil and gas exploration in British Columbia, Canada headwaters of Elk Creek are also looming concerns.

In June, 2008, the U.S. Army Corps of Engineers announced formal adoption of the Variable Flow flood control regime (aka VARQ) for Lake Koocanusa. This represented a long-sought victory of Montana interests in balancing reservoir draw-downs with downstream flows. “The selected plan maintains the current level of flood control benefits in the Kootenai and Columbia River basins while affording the greatest potential operational flexibility to provide a range of flows from Libby Dam to achieve specific habitat attributes expected to benefit the endangered Kootenai River white sturgeon. It also provides flow augmentation for threatened and endangered salmon and steelhead in the Columbia River, and avoids adverse modification of critical habitat to these species.” (USACE Press Release, June 6, 2008).

See the Kootenai River core area summary for additional genetic discussion. There were no brook trout hybrids detected in any of the samples in the Lake Koocanusa core area, and brook trout are generally present in low numbers in drainages inhabited by bull trout. Genetic analysis of bull trout sampled immediately downstream of Libby dam was conducted to determine the significance of entrainment through the dam. Assignment tests of 62 adults indicated half of the fish (31) originated upstream of the dam, and the remaining fish were assigned to likely population origins downstream of the dam. The majority of the 31 fish assigned upstream (17 of 31) were assigned to the strongest known population, the Wigwam River. Most of the rest assigned to the other local populations nearest the dam, Grave Creek in the US and Bloom Creek just upstream of the Canadian border. It is clear that some bull trout are being entrained, but given the robust condition of the Lake Koocanusa core area these losses are not known to represent a problem.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Forest management practices and forest roads** – mostly B.C. headwaters
- **#2 Angling or harvest** (legal or illegal)
- **#3 Entrainment** (hydropower and diversions).

Other activities, currently ranking lower in importance:

- **Mining** (including oil and gas)
- **Water quality impairment from upstream mining and industrial uses**
- **Other** (Reservoir Operations).

The current bull trout population occupying Lake Koocanusa is much more abundant than existed prior to dam construction. The primary concern, from an ESA perspective, is that the vast majority of the spawning and rearing habitat for this core area is located upstream in British Columbia. There are no immediate threats and this population of bull trout may represent the single most significant recovery success story in the entire range of the species.

Operations of the Federal Columbia River Power system have led to extreme variability in the pool level of Lake Koocanusa. While deep draw-downs have been eliminated in recent years, the State of Montana continues to express concern over the effect of water level fluctuation on native fish and recreation. Despite the variable pool elevations, bull trout populations have increased steadily over at least the past decade. As a result, angling and harvest opportunities for bull trout have been restored. The two primary drivers behind the bull trout increase are a robust forage base of small kokanee in the reservoir and high quality bull trout spawning and rearing habitat (mostly in Canada). If either of those attributes were negatively impacted for any reason, bull trout populations would logically experience corresponding declines.

This core area is an important refugia protecting the native genetic stock of Kootenai River bull trout. Extensive BPA-funded monitoring efforts have continued, problem areas for fish passage and habitat have been restored, and a watershed-based restoration program is taking root. Information generated from the experimental bull trout fishery will be used to further refine management of that resource. Bull trout spawning and rearing habitat is well distributed amongst more than a half dozen headwater tributaries, though large proportion of recruitment comes from the Wigwam River drainage in Canada. Both forest management activities and

angler-related impacts to this core area are carefully monitored. Headwater bull trout streams in this region are typically ground water-influenced, but climate change could have a large impact, due to lower elevation and precipitation patterns conducive to frequent rain-on-snow events.

Bull Lake – 1701010111

One adfluvial local population occurs in the Bull Lake core area, Keeler Creek; there is no evidence of resident fish in this core area. Keeler Creek is the primary spawning stream for bull trout in this core area. Monitoring indicates several hundred adult fish (200-500) and the trend appears stable. It is not known whether this core area is functioning at levels of natural abundance, but given the size of the adult habitat in Bull Lake (1,250 acres) the number of adult fish in the spawning population is average or above.

Bull trout in this core area exhibit a complex and relatively unique migratory strategy. Adults from the lake migrate approximately 13 km downstream via Lake Creek, and then up Keeler Creek where most of the known spawning and rearing occurs. There are no known obstacles to this movement. Further downstream in Lake Creek (21 km), there was a natural falls believed to be a historical barrier, which is now the site of the Northern Lights Hydroelectric facility. This barrier has isolated the population, and is located less than 2 km from the Kootenai River. Consequently, bull trout entrained through the power plant are permanently removed from the population.

The Forest Service has conducted a number of recent projects in the Keeler Creek drainage involving road decommissioning and implementing road BMPs, with the expectation that habitat conditions for bull trout in this important drainage will gradually improve; however, there is no monitoring program. A commercial operator is permitted to “pick rocks” for decorative use off gravel bars in the Lake Creek drainage. To date, thousands of tons of rocks have been harvested. The USFS and Conservation District have attached conditions to the operation to minimize any potential habitat impacts and to date no problems have been reported.

See the Kootenai River core area summary for additional genetic discussion. Keeler Creek bull trout exhibited the second lowest levels of genetic diversity and heterozygosity amongst 15 sample populations, which was not unexpected due to the long-term isolation of this population upstream of a barrier falls (and more recently, a hydroelectric facility). Keeler Creek bull trout were markedly divergent from other populations sampled either upstream or downstream of Kootenai Falls and Libby Dam.

Fifty juvenile *Salvelinus spp.* from Keeler Creek were assessed for brook trout introgression. Results indicated 37 fish (74%) were bull trout, 8 fish (16%) were brook trout, and 5 fish (10%) were first generation hybrids. Thus, brook trout are common, bull trout – brook trout hybrids are present in the population, although bull trout still appear to predominate.

In addition, northern pike were recently documented in Bull Lake. There may be an established and expanding population, and the south end of the lake appears to provide suitable spawning habitat for pike. Brown trout also occur in Bull Lake and Lake Creek, but have not been found in Keeler Creek, possibly due to colder water temperatures.

Beginning in 2008, lakes in the western fishing district (including Bull Lake) were opened year-around to angling with two lines. This could potentially result in increased angler bycatch of bull trout (though harvest would remain illegal).

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Fish Passage / Dewatering**
- **#2 Introduced species** – brook trout, brown trout, northern pike
- **#3 Angling or harvest** (legal or illegal) – Bull Lake and tributaries.

Other activities, currently ranking lower in importance:

- **Forest management practices and forest roads**
- **Residential development and urbanization** – Bull Lake and Lake Creek.

It appears that this isolated bull trout core area contains several hundred adult fish (200-500) and the population trend appears stable. This population is unique, with adults migrating downstream of the lake to spawn in Keeler Cr. This core area particularly vulnerable to disturbances in the spawning and rearing habitat given that Keeler Cr is the only known spawning habitat.

Threats to this population by introduced fishes are a concern given that Bull Lake is a small water body with little deep water habitat and multiple demands of water users, recreationists, and landowners. Largemouth bass are well established in the core area as well as brook trout, brown trout, and pike, but the bull trout population does not appear to have been impacted to date.

A few projects have occurred to protect or restore habitat in Keeler Cr. Most of the drainage occurs on National Forest, but the stream traverses private and Plum Creek lands near the confluence with Lake Cr. Particular attention is focused on water quality in this area due to the history and future prospective activity of hard rock mining in the Lake Creek watershed. Sterling Mining Company is pursuing permitting to reopen mining activity at the former ASARCO site. Past water quality impairment in Lake Creek is the result of a copper and silver mine, mill, and tailings impoundment owned by ASARCO, Inc. Climate change is considered a minimal threat due to water temperatures in Keeler Creek being relatively cold and stable, due to ground water influence; the headwaters are not glacially influenced.

Sophie Lake – 170101010404

The most recent information, though largely anecdotal, indicates the migratory-adfluvial component of bull trout in this core area has been reduced to remnant status, at best. The remaining population, in the headwaters of Phillips Creek (in British Columbia), is probably best characterized as “resident”.

The status of bull trout in this core area is identified as a research need, as there is some speculation that bull trout did not naturally occur in the drainage. However, there is a record of bull trout presence going back through documented history of fisheries surveys and extending up to the present. No redds have been located and the lower watershed is largely dewatered during most summers. Based on these observations, this core area is approaching extirpation with little chance of recovery.

There is conjecture that there are plans to improve and perhaps expand the irrigation project on Phillips Creek, in British Columbia. Optimistically, this could result in opportunities for improvements in fish passage, reduced entrainment, and enhanced in-stream flow, but may also further deplete stream flow reaching the US portion of the watershed. There has also been some interest expressed by landowners on both sides of the International Border in riparian and in-stream habitat improvement work, though some of that work could result in further depleting stream flow or create migratory barriers in the form of pond developments.

Non-native species, including a fairly high density of northern pike, now appear to dominate the fish community in Sophie Lake, based on sporadic FWP gill net sampling (M. Hensler, MT FWP, personal communication).

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Dewatering**
- **#2 Agricultural practices**
- **#3 Introduced species**.

This core area is approaching extirpation with little chance of recovery. Threats posed by non-native species are amplified by Sophie Lake being a small water body with little deep water habitat, and multiple demands of water users, recreationists, and landowners. A continued increase in northern pike appears to be occurring and bull trout seem headed toward or already extirpated. Few projects have occurred to protect or restore habitat in the single spawning and rearing stream that traverses mostly private land in the US and British Columbia.

The most recent threat to bull trout in the core area, the northern pike and bluegill illegally introduced in the past decade, have become well established. The complexity of accommodating introduced species into a small closed system where bull trout are vulnerable makes the threat from these illegal introductions extremely high.

In recent years the demand on irrigation water has increasingly intensified on both sides of the International Border. The complete annual summer dewatering of the lower reaches of Phillips Creek, along with associated impacts to the habitat and probable losses through entrainment, are significant threats to perpetuation of bull trout in this core area. Climate change is considered a minimal threat although water temperatures in midsummer in Phillips Creek probably approach levels of concern; primarily due to reduced stream flow, though there is no supporting data.

Clark Fork River Basin

Several core areas have been identified in the Clark Fork River basin in Montana and are summarized. The status and trend of bull trout in many of the core areas within this recovery subunit were considered “unknown” based on information available at the time of listing. Given the significant effort to obtain information for these core areas since 1998, each core area is described separately beginning at the headwaters and progressing downstream.

Clark Fork River (upper) – 17010201

Bull trout in the upper Clark Fork core area have been reduced to four small resident populations in headwater tributaries. Despite restored connectivity with removal of Milltown Dam, this core

area remains heavily fragmented due to a combination of thermal barriers (high summer water temperatures in main stem river and lower portions of tributaries) and dewatering of many tributaries. Adult bull trout are occasionally observed in the Clark Fork River, which may indicate a remnant migratory component that is too small to reliably monitor.

Bull trout populations are heavily fragmented in the upper Clark Fork core area, with a wide variety of threats acting in synergy. Brook trout and brown trout are widespread and abundant throughout much of the upper Clark Fork core area, and able to thrive in degraded systems (temperature, water quality, sediment) where native fish are less viable. Combined effects of over a century of farm and ranch-related land management uses, including irrigation dewatering, grazing, and water quality impairment (temperature, sediment and runoff), have impacted bull trout populations in the core area. Additionally, the legacy of a century of widespread mining abuse is gradually being treated, but will never be fully removed. Forest roads and forest practices are also an ongoing concern. Many of these problems are being systematically corrected, but their legacy endures and in combination, make recovery of bull trout problematic.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Dewatering
- #3 Water quality impairment from non-specific or multiple sources.

Other activities, currently ranking lower in importance:

- Agricultural practices
- Fish passage issues (artificial barriers to migration)
- Forest management practices and forest roads
- Livestock grazing
- Residential development and urbanization.

Some of the highest ranking threats, especially those related to land and water management, fish passage, and dewatering are gradually being reduced in the upper Clark Fork core area. However, threats associated with nonnative species, angling overutilization, water quality and mining legacy, are not readily alleviated and combine to greatly favor native species in this core area. Restoration of migratory bull trout to the upper Clark Fork core area remains very problematic.

Along with the Bitterroot, the upper Clark Fork core area is at high risk from climate change. Populations are already highly fragmented and reverting to the resident life history form, and are restricted to small isolated headwater patches of habitat. A major portion of the main stem habitat is largely unsuitable for occupancy by bull trout in summer. A substantial increase in maximum summer water temperature has occurred over a relatively short period of time, and these temperature increases could be exacerbated by large-scale fire impacts. All of these factors combine to favor non-native species and greatly increase vulnerability of bull trout in this core area to extirpation.

Rock-Flint – 17010202
Rock Cr is one of the most complex core areas for fluvial bull trout in Montana, with perhaps 16 local populations. Movement patterns of migratory fish overlap some resident populations, which makes interpretation of status and trend information difficult. An apparent declining trend in abundance may have been due to natural variation as a result of system-wide drought in recent years. An estimated 250-500 adult fish indicates a decline of well over half in adult abundance in a little more than a decade. The East Fork population, upstream of an impassable barrier dam on East Fork Reservoir, has been more stable than the main core area. This indicates an isolated adfluvial population above the dam, with its own upstream spawning and rearing habitat in East Fork Rock Creek that may warrant establishing as a new core area.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Angling or harvest (legal or illegal)
- #3 Livestock grazing.

Annual estimates in Rock Creek show brown trout populations are increasing and expanding their range upstream, particularly in the middle reaches of Rock Creek. In addition, whirling disease has become established throughout the drainage since about 2000, and may be compounding declines of rainbow and cutthroat trout. While clear cause-effect cannot be established, there appears to be relatively rapid replacement of bull trout by brown trout occurring. The cumulative impact of expansion of brown trout and brook trout, along with whirling disease, is not readily separable from issues of heavy angler use and/or angler-induced mortality of bull trout in this core area. Rock Creek is a highly valued fishery that may be experiencing a level of use beyond what an aggressive and naïve predator like bull trout can sustain in a stream system this small.

The rather stark change in species composition in the Rock Creek core area has occurred over the past decade, with major reductions of rainbow trout and bull trout and a corresponding increase in brown trout. To what extent climate change has, or will play in this change in species composition is unknown. The Rock Creek core area appears to be highly resilient with a high number of local populations and a high level of connectivity. However, upper elevation runoff is limited, and decreased stream flow along with temperature increases in the future could increasingly isolate these populations and lead toward upper elevation isolated resident populations (as has already occurred in the Bitterroot).

Blackfoot – 17010203
There is a strong migratory component to the bull trout population in the Blackfoot R drainage. Less well documented but also present are isolated populations of resident fish in some tributaries within this core area. Two decades of monitoring data indicate a long-term increasing trend occurred from the early 1990's until 2000-2003. Since that peak the population dropped off but appears to have stabilized. Current adult abundance is estimated at 350-500 fish.

Extensive sampling and monitoring has been conducted in the Blackfoot drainage and bull trout distribution is well documented. Five of the six local populations are well connected. While portions of the upper basin suffer dewatering in late summer, improvements include water

diversion upgrades and screening, habitat improvements, and in-stream flow acquisition. The lower main stem Blackfoot River is exceptionally warm during mid-summer and may present a thermal barrier to late migrating fish. The removal of Stimson Dam on the lower Blackfoot and Milltown Dam in 2008 on the main stem Clark Fork immediately downstream of the Blackfoot confluence should provide additional opportunity for genetic exchange and return migration of bull trout from the middle and lower Clark Fork.

The Blackfoot watershed has been a model of conservation planning and habitat restoration for nearly 20 years. Intensive efforts over the past decade include reopening blocked portions of the basin, address acid mine runoff, and point sources of thermal enrichment that may contribute to seasonal fragmentation. As a result of this and positive response from restrictive angling regulations, bull trout occur in formerly unoccupied habitat. Those efforts were also believed largely responsible for the increased abundance of bull trout in the 1990's. The recent population downturn is believed related to decreased in-stream flow and warmer water temperatures resulting from drought. Habitat restoration projects should provide long-term benefits with more favorable flows and additional projects each year. Also, law enforcement activity geared toward bull trout protection has increased and new angling restrictions have been put in place (i.e., no bait) in areas of the main stem Blackfoot and tributaries where incidental catch of bull trout has been problematic.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area are listed in rank order:

- #1a Dewatering
- #1b Livestock grazing
- #1c Water quality impairment from non-specific or multiple sources
- #2 Introduced species/fisheries management
- #3 Forest management practices and forest roads
- #4 Angling or harvest (legal or illegal).

Combined effects of over a century of farm and ranch-related land management uses, including dewatering, grazing, and water quality impairment (temperature, sediment and runoff), are considered to have the greatest existing impacts on the Blackfoot River core area. Many of these problems are being systematically corrected, but their legacy endures. In addition, the effects of introduced species, primarily brook trout and brown trout, which are able to thrive in degraded ecosystems (temperature, water quality, sediment) where native fish are less viable. The legacy of forest roads and forest practices are also an ongoing concern as well as issues with angling over-utilization. The Blackfoot River core area has limited resiliency with a relatively low number of local populations and existing connectivity concerns, which will increase if stream flow decreases; increasing fragmentation is a concern. There is limited information to support increased risk from climate change in this system, but based on current habitat conditions and relative position of the watershed (mostly lower elevation runoff) risk is likely significant.

Clearwater River and Lakes – 1701020310, 170102031101, 170102031102

Most fish in this core area are adfluvial, originating from one of the eight major lakes of the Clearwater chain, but the migratory and genetic relationship among the various lakes is not well understood. There is also some evidence of resident fish in this core area, though poorly documented. Bull trout appear to have been extirpated, or nearly so, from several large lakes

lower in the chain. These declines coincide with increased abundance of northern pike, illegally introduced to this system in the late 1980's or early 1990's. The stronghold of the remaining bull trout population is in the upper lakes of the chain (Seeley, Inez, and Alva Lakes) where gill net catches remain common. The Placid Lake and Salmon Lake populations (lower in the system) are considerably weaker. Though trend data exists only for Morrell Cr it appears that bull trout numbers are low relative to historical conditions (substantially fewer than 1,000 adults), but stable in at least a portion of the upper watershed.

New information conclusively demonstrates the main stem fish passage barriers at Emily-A and Rainy Dams significantly impact connectivity, and likely (perhaps ultimately) bull trout abundance in the core area. In 2009, fishing regulations were changed to close all fishing within 100 yards downstream of these dams, as evidence from recent studies indicated a significant proportion of adult bull trout in the system were being illegally harvested at those two locations.

Recent studies provide clear and convincing evidence of the status and threats to bull trout in this system. However, less is known about the impact of introduced species, especially northern pike, to population levels and long-term stability of bull trout in this unique lake and river system. With reopening of fish passage in the Clark Fork River (e.g., Milltown Dam and Thompson Falls Dam) as well as proximity of the Swan drainage, the potential for a catastrophic introduction of lake trout into this system has increased.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Fish passage issues (Emily-A and Rainy Dams)
- #3 Forest management practices and forest roads.

Introduced northern pike, brown trout, brook trout and other species currently represent the most significant threat because they present hybridization, competition, and predation problems in spawning and rearing habitat, and adult foraging, migrating and overwintering habitat. Nearly the entire bull trout population of this interconnected lake and river system (with the exception of the extreme headwaters) is affected. Non-native species issues also impact spawning and rearing habitat, as well as foraging, migrating, and over-wintering habitat. Continued declines in bull trout appear imminent in this core area.

Transfer of Plum Creek lands to the Nature Conservancy, and ultimately to Montana Department of Natural Resources Conservation improves the prospects of long-term habitat protection, though details remain unclear as to the degree of those protections. Also, there is limited information to support increased risk from climate change in this system, but based on current habitat conditions and relative position of the watershed (mostly lower elevation runoff) risk in this watershed is likely significant. The primary thermal refugia in smaller lakes will shrink and warming surface water temperature increases could be compounded given that water flows through a series of interconnected lakes. The extent of spawning and rearing habitat, which may also become increasingly fragmented, is perceived as particularly at risk in the West Fork, and Marshall Creek.

Clark Fork River (middle) – 17010204

Most fish in the middle Clark Fork core area are fluvial migrants that originate from the Clark Fork River, although an increasing portion may be adfluvial, originating from Lake Pend Oreille or within the main stem reservoirs as fish passage is enhanced. Trend data indicate an adult population of around 200 fish is roughly stable, but at low density. Confidence in this trend is limited because there are very few adult fish spread over a very large area. Six local populations were designated in the Draft Recovery Plan, with two more resident populations recently recommended. Most local populations are well below historical levels of natural abundance and inadequate to maintain long-term genetic viability.

Recent extensive surveys in the middle Clark Fork core area indicate bull trout are scattered throughout suitable habitats at very low densities, making rigorous distribution and abundance estimates difficult. Telemetry studies have highlighted the importance of coldwater sanctuaries at the mouths of tributaries as thermal refugia during summer months; those fish subsequently migrated into the tributaries to spawn. In Rattlesnake Creek, marked fish were moved above a dam (which has since been fitted with a fish ladder) continued upstream several miles to spawn, but generally returned to the middle Clark Fork River to over-winter before returning for consecutive year spawning runs.

Several actions have been taken in the past few years to restore connectivity for migratory bull trout in the middle Clark Fork River core area. This includes a trap and haul fish passage program at Cabinet Gorge and Noxon Rapids Dams, and a planned fish ladder at Thompson Falls Dam in the lower Clark Fork core area; installation of fish passage at the Mountain Water Co. Dam on Rattlesnake Creek, and removal of Milltown Dam at the upstream end of this core area. These actions will enhance fish movement in and out of the middle Clark Fork core area. Six of eight local populations (two recently proposed) are fully connected within the core area. In the future, fragmentation will be more a matter of habitat suitability due to high summer water temperatures. Limited thermal refugia at the confluence and in lower reaches of cold water tributaries play an extremely important role in maintaining connectivity for bull trout in the core area.

While conditions have trended upward in upper elevation habitat patches on federal lands in the middle Clark Fork core area, residential development and timber harvest on private lands have increased at lower elevations. Much of this activity is concentrated at the lower ends of key tributaries where bull trout are known to congregate and may be increasingly vulnerable. In the past five years, low stream flows and the warmest water temperatures on record have also been documented. Given the circumstances, it would be difficult to state the overall habitat trend is improving in this core area.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Forest management practices and forest roads
- #3 Angling or harvest (legal or illegal).

Other activities, currently ranking lower in importance include:

- Fish passage issues (artificial barriers to migration)

- Residential development and urbanization
- Water quality impairment from non-specific or multiple sources.

In the middle Clark Fork core area, over half of the spawning and rearing habitat as well as the entire main stem foraging, migrating, and over-wintering habitat are occupied by brown trout and/or brook trout. The combination of predation, competition, and hybridization threats with reduced habitat quality (largely a legacy of forest management in the tributaries), major dams, elevated water temperature, and degraded water quality on the main stem, results in limited resiliency for migratory bull trout. Additional significant habitat limitations (e.g., dewatering, thermal enrichment) render full recovery of bull trout an uncertain prospect at best. Potentially, this core area should be able to support >1,000 adult bull trout. Thus, the emphasis has been placed on connectivity to restore this core area as a functioning portion of a larger complex of core areas.

Bull trout have persisted in the middle Clark Fork core area despite over 100 years of abuses to the system. This persistence provides a measure of confidence that the intensive habitat and ecosystem measures currently being undertaken will provide systematic reconnection and restoration that can reverse a century of decline. Climate change is expected to impact this core area, due in part to lower the elevation, and precipitation patterns conducive to rain-on-snow events. In addition, there are major concerns with main stem Clark Fork River water temperatures that are marginally suitable for bull trout in summer. Combined, these factors favor introduced species and increased fragmentation of local bull trout populations.

Bitterroot – 17010205

The Bitterroot core is highly fragmented and much of the main stem Bitterroot River as well as the lower reaches of many tributaries are unsuitable for bull trout (warm water temperatures and dewatered) in summer. This core area is comprised primarily of isolated resident populations, with a much diminished and apparently declining fluvial component. Nine local populations are designated with a suggested 10th. However, recent surveys found six additional resident bull trout populations isolated in west side tributaries that flow out the Selway Mountains; in all cases the populations occupy only a few miles of stream, spawning was documented, upstream reaches were fishless, and downstream portions are dewatered in summer months. No trend is discernible from the sparse data for this core area, due largely to the combination of very few fluvial bull trout and the remaining resident populations being fragmented if not isolated.

The Bitterroot River is an example of a watershed where systematic decline of the migratory fluvial life history form of bull trout has resulted in increasingly isolated and fragmented populations of resident fish. To date the drainages studied had no physical barriers to migratory fish, indicating that other downstream mortality factors such as predation or temperature played a role in the extirpation of the migratory form. The isolated, non-migratory remnant populations are believed to be at increased risk of extinction, and restoration of the migratory form is an important conservation goal.

Much of the fragmentation that occurs in this watershed is due to natural dewatering of ground water-fed tributaries before reaching the Bitterroot River. Most of these cases are exacerbated by irrigation withdrawals, and there are several large irrigation structures and flumes that mix water sources and complicate connectivity. Most are not screened. In addition, the West Fork

Dam severs the upper Bitterroot River from a major portion of the best spawning and rearing habitat in the system, creating a separate core area upstream.

In 2001 and 2003 unusually large and high intensity fires burned large portions of the bull trout habitat in the Bitterroot River drainage. No immediate short-term impacts to bull trout populations were noted as a direct result of the fires or post-fire conditions, and sediment transport was minimized due to burned area rehabilitation activities and favorable runoff conditions. Recent analyses of temperature data from 33 streams in a variety of burned and unburned watersheds documented a significant overall increase in late-summer water temperatures over the past 12 years in all streams. In addition, there was no significant recovery of colder stream temperatures in burned areas five years post-fire. It appears that while the fires had localized, long-term impacts on water temperature, the watershed-wide changes in temperature may be attributed to climate change. Regardless of the cause, these findings suggest bull trout habitat may be further contracting, further reducing habitat patch size, and population fragmentation is likely to increase.

Upstream range expansion of brook trout is suspected in at least two of eight tributary streams in the Bitterroot core area. However, it is unknown whether these observations are actual expansion or previously undocumented occupancy. Increasing stream temperatures will likely permit upstream expansion of some brook trout and brown trout populations. Brown trout populations in the main stem Bitterroot River are documented as increasing in recent years and whirling disease has also been documented in the Bitterroot River drainage.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Dewatering**
- **#2 Introduced species/fisheries management**
- **#3 Residential development and urbanization**.

Dewatering, both natural and artificial, and the resulting fragmentation of bull trout habitat that results, combined with the synergistic effects of climate change and post-fire increases of stream temperature, represent the greatest threat to bull trout in the Bitterroot core area. These same factors combine with, and are exacerbated by, increasing populations of brook trout and brown trout, and increasing levels of urbanization along stream corridors.

The Bitterroot core area may be at greatest risk from climate change. Populations are already highly fragmented and reverting to the resident life history form, and often restricted to small isolated headwater patches of habitat. A major portion of the main stem habitat is largely unsuitable for occupancy by bull trout in summer. Substantial increase in maximum summer water temperature is occurring over a relatively short period of time, exacerbated by recent landscape scale fire impacts. All of these factors combine to greatly increase vulnerability of this core area to extirpation.

Clark Fork River (lower) – 170102012, 17010213

Most fish in the lower Clark Fork core area originate from Lake Pend Oreille or within the three main stem reservoirs. There is evidence of fluvial bull trout in this complex core area, and resident bull trout have been documented in upper reaches of Rock Creek and Prospect Creek,

upstream of partial or complete barriers. Fourteen local populations have been identified, and one additional population has been recommended, Swamp Creek in the Noxon Reservoir segment. Trend data indicates a population that is stable and perhaps increasing, with a minimum adult population approaching 500 fish. No trend information is available for the lower Flathead River portion of the core area, where numbers of bull trout are generally very low.

The lower Flathead River portion of this core area is almost entirely on the Flathead Reservation of the Confederated Salish and Kootenai Tribes. Data from Tribal monitoring programs is not public information, though it is known that trend data is being collected routinely for this local population. In addition, extensive bull trout restoration is occurring in the Jocko River watershed, where most of the bull trout habitat in the lower Flathead core area occurs. Information from informal discussions with Tribal representatives indicates that numbers of adult bull trout in this core area are generally low, on the order of 100 adult fish or fewer in the migratory population.

Much of the recent progress on the lower Clark Fork core area has occurred following FERC relicensing agreements for Avista Corp. and PPL Montana. The Avista Native Salmonid Restoration Program is conducted under a multi-partner agreement that authorizes continued operation of Cabinet Gorge and Noxon Dams. PPL Montana has proposed to move forward with construction of a permanent upstream fish passage ladder at Thompson Falls Dam. FERC license conditions set in-stream flows and reservoir elevation, and directed Avista to fund activities that address options for upstream passage of adult fish, provide safe passage for juvenile fish downstream, experiment with control of non-native species in selected waters, monitor fish abundance and distribution, evaluate and mitigate gas super-saturation, and conduct research that emphasizes native species restoration. In addition, a great deal of information has been gained from surveys on tributary drainages under the Plum Creek Native Fish Habitat Conservation Plan.

Major fish passage barriers in the Clark Fork River core areas (Cabinet Gorge Dam, Noxon Rapids Dam, Thompson Falls Dam, Milltown Dam) are being gradually reduced or eliminated (Thompson Falls fish passage planned for 2010). Until fish passage is restored at the Cabinet Gorge and Noxon Dams, adult and juvenile trap and transport strategies are being implemented to reduce impacts. As a result, fragmentation is being reduced and connectivity restored, diminishing the highest ranking threat. However, non-native species (brook trout, brown trout, lake trout, northern pike, and walleye) are increasingly impacting efforts to recover bull trout, and habitat in the reservoirs favors many of the introduced fishes over native species. Thus, the combined impacts of dams and non-native fish present in the reservoirs on the Clark Fork River are expected to remain the highest ranking threats into the future.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Fish passage issues (artificial barriers to migration)
- #2 Introduced species/fisheries management
- #3 Forest management practices and forest roads.

Other activities, currently ranking lower in importance include:

- Entrainment (hydropower and diversions)

- Water quality impairment from multiple sources (temperature and Total Dissolved Gas)
- Dewatering.

Bull trout have persisted in portions of the highly fragmented and degraded lower Clark Fork core area for nearly 100 years. This provides a measure of confidence that the intensive habitat and system-wide measures currently being undertaken will provide systematic reconnection and restoration that can reverse a century of decline. While bull trout will never be restored to their original status, incremental improvement should be possible.

Headwater habitat patches occupied by bull trout in this region are typically ground water-influenced. Climate change is expected to impact this core area due to the lower the elevation, and precipitation patterns conducive to rain-on-snow events. In addition, there are major concerns with main stem Clark Fork River water temperatures that are marginally suitable for bull trout in summer, and the continued loss of suitable bull trout habitat in the main stem reservoirs. Combined, these factors favor introduced species and increase population fragmentation.

Flathead Basin (above Kerr Dam)

Several core areas have been identified in the Flathead River basin in Montana and are summarized. The status and trend of bull trout in several of the core areas within this recovery subunit were considered "unknown" based on information available at the time of listing. Two of the core areas have the most extensive information available for bull trout status and trend. Given the significant effort to obtain information for either the core areas with unknown status, or those with a robust base of information, each core area is described separately.

Flathead Lake – 17010206, 17010207, 17010208

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is little or no evidence of resident fish in this core area. Apparent fluvial fish have been documented in the mainstem Flathead River above the lake. Nineteen local populations have been identified, and the 2008 basin-wide monitoring indicated an adult bull trout population of at least 1,500 fish.

The Flathead Lake watershed is one of the largest, most complex, and best-documented bull trout core areas in the upper Columbia River basin, encompassing 125,000-acre Flathead Lake (the largest freshwater lake in the US west of the Mississippi River) and a large portion of northwest Montana extending into British Columbia, Canada. An extensive spawning and spawning habitat monitoring program was developed by Montana Fish, Wildlife, and Parks and implemented since 1980. Redd counts and substrate assessments have been conducted annually in seven index streams in the North Fork and Middle Fork Flathead River drainages. Based on these counts, the recent trend in adult bull trout abundance appears stable, though well below numbers observed in the 1980's.

While the recent five-year trend for bull trout redd counts appear relatively stable in the Flathead Lake core area, there is increasing debate about the security of the core area population given heavy lake trout and northern pike predation pressure. There is no evidence that the brook trout threat in this core area has expanded or is a significant issue. Even at the recently observed level

of stability, given the reactive nature of redd counts as a primary indicator, there is concern that declines could occur more quickly than could be accounted for. For species that have presumably already declined to low levels, an inability to quickly detect further declines in population abundance is a serious matter. Managers are examining another method (termed Viable Population Monitoring or VPM) that would incorporate greater randomness in sampling and increase power to detect change in redd counts, but have not yet adopted it.

In the longer term, basin-wide counts were made sporadically in 10 of the 30 survey years, representing all 31 stream sections known to be used by Flathead Lake adfluvial migrants. The basin-wide total has ranged from lows of 236 (1997) and 291 (1992) to highs of 1,156 (1982) and 850 (1986). The basin-wide count of 503 for 2008 was the fourth lowest, though not far off the 10-year average of 578.

Despite the size and complexity of this core area, it has been extensively sampled and existing bull trout distribution is well-documented, although typically not through applying a statistically rigorous presence/absence protocol. No significant changes in overall distribution have been observed; although there appears to be an increasingly stronger reliance on the upper N FK Flathead R for spawning, based on recent redd counts. There is no doubt that current bull trout numbers remain significantly below 1980's levels, but whether bull trout have substantially rebounded from the prelisting lows of the early 1990's is not yet clear. Concerns remain for some formerly strong local populations (e.g., Coal Creek, N FK Flathead R) where redd counts remain at an especially low ebb, occasionally reaching zero.

Though Hungry Horse Dam on the South Fork Flathead River removed a substantial portion (up to 40%) of the spawning and rearing habitat, the integrity and connectivity of the remaining habitat in the North and Middle Fork drainages of this core area is high. Hungry Horse now functions as an independent core area. Flathead Lake is a large core area with several natural barriers in headwater streams, above which are small isolated core area populations. While occasional temporary barriers result from beaver dams or other natural mass movement events, there are no known man-caused barriers on bull trout spawning and rearing streams.

In 2001 and 2003 major fires burned large portions of the bull trout habitat in the N FK and M FK Flathead R drainages. While these events are part of long-term natural cycles in these lodgepole pine and Douglas fir ecosystems, the scope and severity of the fires was unusual and may have been exacerbated by a history of 20th century fire suppression activities on the forests. No immediate short-term impacts to bull trout populations were noted as a direct result of the fires or post-fire conditions and sediment transport was minimized due to burned area rehabilitation efforts and favorable runoff conditions.

Considerable new information has been developed in recent years indicating a generally improving trend in bull trout habitat in this core area. In general, bull trout spawning and rearing habitat is either located in congressionally designated wilderness, Glacier NP, or in portions of National Wild and Scenic River corridors. Private land ownership is limited and on much of the N FK Flathead R there has been minimal development of new roads or timber sales and a strong emphasis on road decommissioning and application of best management practices (BMP). Some concerns remain due to potential for long-term increases in water temperatures and future effects of rain-on-snow precipitation patterns in burned areas. More recently, additional emphasis has

been placed on identifying and evaluating important bull trout habitat in the British Columbia headwaters of the N FK Flathead R, given threats of expanded coal, oil and gas exploration and development. Surveys have been completed on over 25 stream reaches for fish species distribution and genetic samples in Canadian tributaries to the North Fork; westslope cutthroat trout, bull trout and sculpin were observed in many reaches.

The US Fish and Wildlife Service's Biological Opinion on the operations of the Federal Columbia River Power System assessed impacts of system operations at Hungry Horse Dam on bull trout. The operations of the dam are reviewed on a regular basis and the FWS is routinely consulted on operational changes that are constantly needed in an attempt to balance species needs against other downstream ESA concerns (listed salmon and steelhead), hydropower demand, flood control and storage, and other factors. Management strategies and operational scenarios are in a constant state of flux. Multiple aspects of bull trout recovery are incorporated into (and funded through) the Bonneville Power Administration Fish and Wildlife Program, and guided by the Northwest Power and Conservation Council. The most recent effort in that regard includes a subbasin planning effort for the Flathead basin. On a positive note, full implementation of the selective withdrawal system at Hungry Horse Dam has restored more normative flow and temperature regimes to the mainstem Flathead River downstream of the S FK Flathead R confluence.

Results of a basin-wide genetic analysis of microsatellite and mitochondrial DNA markers of 14 local populations of bull trout from throughout the Flathead basin (including the South Fork and Swan drainages) showed a large proportion of the observed population differentiation was attributable to genetic differences among populations within drainages. This indicates that even geographically adjacent local populations are reproductively isolated, and raises concerns that were local populations extirpated there is a low probability of recolonization through dispersal from adjacent populations. The lack of evidence for a metapopulation structure that exhibits frequent extinction-recolonization events in this core area places a greater emphasis on maintaining all local populations. No results are available for recent genetic samples collected in the British Columbia tributaries to the N FK Flathead R.

Extensive monitoring of the Flathead Lake ecosystem, including bull trout and associated fish species (especially lake trout, westslope cutthroat trout, and lake whitefish) occurs under a joint agreement between Montana Fish, Wildlife and Parks and the Confederated Salish and Kootenai Tribes and is guided by principles described in the Flathead Lake Cooperative Management Plan. The investigators are evaluating numerous aspects of the complex food web interactions that occur in this system and that were disrupted as a result of the introduction and establishment of *Mysis* shrimp in the early 1980's, and reverberated through the food chain. These events were ultimately determined to be responsible for the collapse of a formerly strong population of kokanee salmon and the establishment of *M. relicta*, which fueled major increases in lake trout and lake whitefish populations. Predation, competition, or other forms of negative interaction with lake trout is the single factor most responsible for the decline of bull trout in this core area. Collective assessment of the research and monitoring program indicates that the lake trout population has stabilized at a high level and that bull trout redd numbers are currently below levels necessary to sustain long-term viability.

No change has been detected in the disease status; whirling disease has not been documented in the core area. The effects of predation and competition in Flathead Lake and the mainstem Flathead River remain unsettled and of major concern. A summary and discussion of the most recent status indicates that Flathead Lake anglers harvested about 45,000 lake trout in 2008, short of the goal of 60,000. Catch per unit effort and species composition of the 2008 lake-wide gill net catch were similar to catches in recent years, but numerous indicators suggest the lake trout population remains stable or potentially increasing. Pike numbers also appear relatively stable, but bioenergetics modeling indicates northern pike consume over 13,000 westslope cutthroat trout and nearly 3,500 bull trout annually in the core area. On a positive note, a reproducing brown trout population in Mill Creek, downstream of Creston National Fish Hatchery appears to have been successfully extirpated. However, black crappie have been illegally introduced into a number of interconnected lakes and appear to be established and spreading. Scattered reports of smallmouth bass have also occurred. In summary, while there's little evidence that competition or predation interaction with non-native species has increased, neither has the problem been reduced.

Lake trout limits were expanded to 50fish daily and in possession, but may have had limited impact on overall harvest as this far exceeds the number most people are willing or able to keep and consume. Beginning 2009, extended pike harvest will be allowed in the Flathead River December through February, though still closed to harvest during March through the third Saturday in May. Bycatch of bull trout is known to occur in the lake trout and pike fisheries, as well as at certain river locations, but is mostly unintentional and has proven difficult to regulate or reduce. The number of fishing outfitters is capped by USFS Recreational Use permits, but outfitter days are not capped and have slowly increased, along with non-outfitted recreational fishing in the Flathead River and its forks. Overall, it is difficult to quantify the amount of legal over-utilization and illegal angling (poaching) that is occurring and its effects on bull trout. The mainstem Flathead River upstream of the lake, the north end of the lake near the Flathead River inlet, and confluence of certain streams such as Big Creek are known problem areas. Use for scientific and educational purposes also occurs, but is more closely monitored and regulated.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Forest management practices and forest roads
- #3 Angling or harvest (legal or illegal).

The non-native species threat (especially lake trout and *Mysis*, but also northern pike and other warm water fish) poses the greatest ongoing risk to bull trout in this core area. Forest management is currently being mitigated by BMPs and other actions are much reduced in scope. Population response of bull trout to fishery management actions is not certain, given the non-native species concerns.

Information collected since the time of listing indicates the status of this core area remains static at best. The magnitude of the lake trout threat has not declined and some local populations are at precariously low levels. Magnitude and imminence of existing non-native species threats remain high, despite management efforts to mitigate them. Recent (2004) efforts by the British Columbia government to auction coalbed methane leases and more recently to reopen

exploratory coal mines (2005) in the headwaters of the N FK Flathead indicate the magnitude and imminence of threats to habitat and water quality in this contiguous trans-boundary system are elevated.

Flathead is a large, deep, cold lake with many ground water-influenced spawning and rearing streams and a huge expanse of interconnected habitat. For that reason, the core area should be relatively immune to climate change concerns, although site-specific impacts could occur in some tributaries. Precipitation patterns appear conducive to a higher frequency of rain-on-snow events in certain watersheds, as has been exhibited in recent years.

Cyclone Lake – 170102060306, 170102060304, 170102060305, 170102060307, 170102060309, 170102060211, 170102060212

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area.

Annual monitoring of redds in Cyclone Cr at the outlet of Cyclone Lake, the only known spawning location for bull trout in this core area, has occurred since 1993. In the 16 years of record, redd numbers ranged from zero to five, with no redds recorded in 1997-2002, and 2004. Anecdotal reports of bull trout catches from the lake are received regularly and some bull trout redds are observed annually in portions of the Coal Creek drainage.

The adult population of bull trout in Cyclone Lake is much less than 100 individuals. No bull trout were captured in the lake during 2007 gill net sampling, and the trend is roughly stable, but with a relatively short time series of redd counts and low power to detect change. This core area is thought to be functioning well below historic levels of abundance.

Bull trout from this core area have complete connectivity with the much larger Flathead Lake core area, immediately downstream (Cyclone Cr is tributary to Coal Cr). In standard electrofishing surveys of upper Coal Cr a lake trout was captured for the first time in 2006. This has led to increased concern that Cyclone Lake could be invaded and potentially compromised. Consideration is being given to creating an artificial barrier to isolate the system.

Fish in this lake have been known to be plagued with infestations of “black spot disease”, caused by the trematode cercariae (e.g. *Neascus spp.*). Snails, piscivorous birds, or fishes are common links in the transmission cycle. Usually, poor water quality, high water temperature and presence of aquatic snails or other invertebrates are essential to the life cycle of this fish parasite. While black spot has not been specifically noted in bull trout and has not been documented as threatening bull trout populations, its prevalence is sometimes taken as an indicator of marginal habitat for a cold-water salmonid.

The status and trend of bull trout in this core area were considered “unknown” based on information available at the time of listing. Recent sampling indicates the core area population is minimally viable. The small scale of this core area, combined with ongoing habitat impacts (past logging) indicate limited probability for bull trout recovery and extirpation in this core area is possible, if not imminent.

The relationship between this core area and downstream portions of the Coal Cr local population are not well-defined. A Total Maximum Daily Load (TMDL) study is currently being developed

for Coal Cr, which may help define some aspects of ecosystem health, which is currently depressed in the entire watershed. Since the Cyclone Lake core area is mostly located on the Coal Creek State Forest, the State of Montana is largely responsible for management of this watershed. However, state bull trout conservation efforts are largely directed to other core areas.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Angling or harvest** (legal or illegal)
- **#2 Forest management practices and forest roads**.

The combination of existing habitat degradation and marginal viability of bull trout in this core area, as well as easy access by vehicle and occurrence of lake trout in the vicinity, leads to moderate threat severity. In addition, the lake is relatively shallow and may have limited suitable bull trout habitat in the summer.

There is no indication that the threats are any more immediate now than they have been in the recent past. Limited available habitat information suggests the Cyclone Lake core area is under moderate threat from climate change. The lake is small and shallow with no significant inflow from tributaries, and bull trout spawning and rearing is confined to the outlet stream. Consequently, increased summer warming of surface waters could render the water temperatures unsuitable for bull trout.

Whitefish Lake – 170102100506

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area. One or possibly two local populations are present.

Annual redd monitoring in two index streams, Swift Cr and West Fork Swift Cr, has been conducted since 1994. Number of redds ranged from 2 to 17. The latter, in 2007, represents the highest combined total since monitoring began. The information indicates this bull trout core area currently supports fewer than 100 adult fish and the trend is not certain; monitoring has been too sporadic to detect change.

Habitat connectivity is good, with no barriers in the system between Whitefish Lake and upstream spawning and rearing habitat. Downstream of Whitefish Lake, the Whitefish River (approximately 25 miles) is unobstructed to the Stillwater, which then joins the Flathead River upstream of Flathead Lake. Much of the habitat is degraded and water temperatures are extremely warm during summer. The watershed has an extensive road network, as well as roads in close proximity to the mainstem of Swift Cr and W FK Swift Cr. The legacy of past land management practices, primarily timber harvest, and relatively high fine sediment levels (30-40%) has clearly impacted bull trout.

There are growing concerns that the lower portion of Swift Cr (the migratory corridor), which is primarily in mixed ownership (Plum Creek, private and state timberland), will be intensively developed as residential properties. Most of the drainage, including the spawning and rearing habitat, is located in the Stillwater State Forest. An HCP for bull trout and native fish is being completed by Montana DNRC, with a take permit scheduled to be issued in 2010. There is

uncertainty whether the Plum Creek lands would continue to be included under the Native Fish HCP if developed for residential use and to what extent those protections would be effective.

The native fish assemblage of Whitefish Lake is severely comprised, and it is doubtful whether the food web can be stabilized or managed to favor bull trout recovery. Native westslope cutthroat trout, mountain whitefish, and introduced kokanee have declined precipitously. Bull trout recovery in this core area has been severely compromised by the combination of high densities of non-native *Mysis* shrimp, lake whitefish and lake trout (essentially recreating a Canadian Shield lake ecosystem).

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Forest management practices and forest roads.

Other activities, currently ranking lower in importance include:

- Angling or harvest (legal or illegal)
- Residential development and urbanization
- Water quality impairment from non-specific or multiple sources.

The status and trend of bull trout in this core area was considered "depressed" and "declining" based on information available at the time of listing. Threats posed by non-native species and degraded habitat conditions, combined with a high proportion of the drainage in heavily managed timberlands potentially subject to development; make long-term prospects for bull trout in this core area rather dim. Particularly given that the population is distributed in only one or two headwater tributaries. Recent addition of the piscivorous northern pike in the core area makes extirpation of bull trout a distinct possibility.

The Plum Creek HCP includes several sections of land positioned low in this watershed, but most state and private bull trout conservation and restoration efforts are being directed to other core areas. There is no available information to indicate elevated risk from climate change, although the degraded habitat and relative position of the watershed likely increases risk of elevated water temperatures. In addition, the low elevation and north-south aspect of the drainage are conducive to an increased frequency of rain-on-snow events.

Upper Whitefish Lake – 170102100502

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area, however, some fish may be partly or wholly fluvial.

Annual redd monitoring has occurred in the East Fork Swift Cr, the presumed location of spawning for bull trout in this core area, since 1993. In the 12 years of record, not a single redd has been located. However, anecdotal reports of bull trout catches from the lake are received regularly and up to 14 bull trout redds have been observed annually a few miles away in downstream portions of the mainstem of Swift Cr and West Fork Swift Cr. Those redds have been historically attributed to the Whitefish Lake core area, downstream.

There is doubt about the status of this small lake (88 ac) as a viable core area. If bull trout were historically present, there is little evidence that they persist today. The adult population in this lake appears reduced to a handful of individuals with no evidence spawning for roughly two generations. It is probable that this core area is functionally extirpated and there are only remnant individuals straying from adjacent core areas.

The legacy of past clear-cutting and road construction in the E FK Swift Cr headwaters persists. Annual dewatering of the inlet of E FK Swift Cr has occurred for 20+ years, largely as a result of natural events but probably aggravated by past forest management induced debris flows. The stream now flows subsurface for most of the summer just upstream of the lake, precluding the possibility of bull trout spawning and no juvenile rearing has been detected in recent years.

Heavy public use of developed camp sites on the shore of this small alpine lake lead to conclusions that angling has a negative effect on the limited number of bull trout in the core area. However, no documentation is available. Montana FWP stocks the lake with westslope cutthroat trout to provide a recreational fishery, exacerbating the high angling pressure. Montana FWP statewide angling use estimates, conducted every other year by mail survey, indicated that angler days on Upper Whitefish Lake averaged 465 per year in the 1990's and 519 in 2001-2005. This equates to almost six angler days per acre and may be beyond that which bull trout can sustain in such a small system with limited spawning and rearing habitat.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Dewatering
- #2 Angling or harvest (legal or illegal)
- #3 Forest management practices and forest roads.

The status and trend of bull trout in this core area were considered "unknown" based on information available at the time of listing. While it is accepted that bull trout were formerly more abundant in this core area, it is unknown whether extensive spawning and rearing occurred in the E FK of Swift Creek prior to the intensive forest management practices and high angler use. Hence, there is no baseline for comparison, though it is known this population is severely depressed and extirpation is a possibility, if it has not already occurred.

Each of the primary threats currently acts to suppress this population. Because of the marginal viability and low numbers of bull trout in this core area and the easy access by vehicle leading to high angler use, the severity of threats is considered high. There is limited available information to assess the likely impacts of climate change, but the lake is small and shallow with no significant surface inflow from tributaries. Bull trout spawning and rearing is confined to the outlet stream. Consequently, any increase in summer water temperature is likely to render the lake unsuitable for bull trout.

Upper Stillwater Lake – 170102100105

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area, however, some fish may be partly or wholly fluvial. One or possibly two local populations are present in the Stillwater River and Fitzsimmons Cr.

Annual redd monitoring in a reach of the upper Stillwater R has occurred since 1994. These index counts ranged from two to 16 prior to listing and have trended higher (12-35) since 1998; no counts were conducted 2004-2006. There is uncertainty whether these fish are primarily fluvial or adfluvial, and an abundance of brook trout in the system raises concerns regarding the adequacy of redd counts as an accurate population index. These data indicate fewer than 200 adult bull trout in this core area, and with extremely low numbers remaining in Upper Stillwater Lake the trend is uncertain. However, juvenile abundance monitoring in recent years indicates high juvenile densities in the spawning and rearing habitat of this core area.

The recent 10-year period indicates increased juvenile abundance, which along with the increasing number of redds counted is inconsistent with data suggesting very few, if any, adfluvial adult bull trout persist in Upper Stillwater Lake; intense competition and/or predation with northern pike and lake trout in the lake is suspected. Little is known regarding bull trout distribution in the core area, but this system may be undergoing a conversion to a fluvial or resident life history.

Habitat connectivity is good, and there are no barriers between Upper Stillwater Lake and upstream spawning and rearing habitat. There are aging wooden dams on the outlets of Upper and Lower Stillwater Lakes which may impede upstream passage at some flows. The Stillwater R is otherwise unobstructed to the Flathead River upstream of Flathead Lake (approximately 55 miles), but much of the habitat is degraded and water temperature is extremely warm in the summer. The upper Stillwater R watershed has an extensive road network, and there are concerns with the legacy of land management practices (primarily forestry). Several major runoff events have occurred in recent years resulting in application of BMP improvements to most of the road system.

Genetic analysis in 1993 indicated a unique departure from normal allele frequencies (n = 25 juvenile) in bull trout collected from the upper Stillwater R. All fish were heterozygous at a particular allele, suggesting they were full siblings from a single mating. Given that only two redds were observed in 1995, indications are the population may have experienced a genetic bottleneck, but no further evaluation has occurred.

Brook trout remain abundant throughout the drainage and some bull trout-brook trout hybrids have been observed. No recent quantitative data is available. Previous documentation indicated a strong, reproducing population of northern pike in Upper Stillwater Lake resulted from an illegal introduction in the early 1970's. In about 1995, lake trout were also detected in the lake and have since established a reproducing population. Lake trout up to 15 pounds were reported in angler catches, and distribution has extended upstream into the Stillwater River system. It is unlikely that bull trout persist in any numbers in Upper Stillwater Lake, given the strong presence of these two competing species. More recently, black crappie were illegally introduced into Lower Stillwater Lake.

Most of the drainage, including the spawning and rearing habitat, is located in the Stillwater State Forest. An HCP covering native fish is being completed with Montana DNRC, with a take permit scheduled to be issued in 2010.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- #1 Introduced species/fisheries management
- #2 Angling or harvest (legal or illegal)
- #3 Forest management practices and forest roads.

The lake habitat appears to be seriously and perhaps permanently compromised for native species. Despite an apparent decline in adfluvial bull trout in the core area, apparent increases in both redd counts and juvenile abundance have been observed. These seem to be inconsistent trends making this core area a bit of an enigma, which would benefit from additional research efforts.

The status and trend of bull trout in this core area was considered "depressed" and "declining" based on information available at the time of listing. Recent information suggests low numbers of adult bull trout remain (<200), and no particular recent trend is evident. There is low confidence in the use of redd counts as an index in this core area due to the decline of large adfluvial bull trout and the abundance of brook trout that may overlap the spawning area. The robust population of northern pike and recent introduction of non-native lake trout offer limited prospects for bull trout recovery in the lacustrine habitat of this core area and the future of fluvial or resident stocks that are increasingly isolated in the headwaters is not certain. Whether the food web in the lake can be stabilized or altered to favor bull trout recovery is in doubt.

The threats posed by non-native species, combined with a high proportion of the drainage in heavily managed timberlands, make long-term prospects for bull trout in this core area rather tenuous. Especially given that the entire population is distributed in one or two headwater tributaries. It is unknown what effect potential conversion from an adfluvial to a fluvial or resident population may have, but the resiliency built in to multiple bull trout year classes in the lake habitat appears to have been compromised.

There is no available information to indicate risk to this core area posed by climate change, although the degraded habitat and relative position of the watershed likely increases risk of elevated water temperatures. In addition, the low elevation and north-south aspect of the drainage are conducive to an increased frequency of rain-on-snow events.

Swan Lake – 17010211

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area.

Redd count and juvenile abundance monitoring for a 26-year period indicate a population that has declined from a peak in the 1990's, and been stable for the most recent five-year period. Bull trout appear to have reached equilibrium in this system at a population level of about 2,000-3,000 adults. However, there are major concerns given the expanding lake trout population in Swan Lake and potential impacts that may have in the future.

Access to some portions of potential spawning and rearing habitat are restricted by barrier falls (e.g., Lion Creek), beaver dams (e.g., Jim Creek), or highway culverts (e.g., Cooney Creek), but overall the degree of connectivity and relative amount of spawning and rearing habitat is high.

Bigfork Dam has potentially restricted downstream movement and precluded return of fish from Flathead Lake for most of the past century, and is now a complete barrier.

An extensive basin wide genetic analysis was completed in 2001 using microsatellite and mitochondrial DNA markers on 14 local populations of bull trout throughout the Flathead Basin (including the South Fork Flathead and Swan drainages). A large proportion of the observed population differentiation was attributable to genetic differences among local populations within drainages, which suggests that even geographically adjacent local populations isolate reproductively. This indicates that extirpated local populations would have a low probability of recolonization through dispersal from adjacent populations. There was no evidence of a metapopulation structure exhibiting extinction-recolonization events in this core area, and reinforces the need to maintain all local populations.

A baseline evaluation of bull trout-brook trout hybridization was completed in Goat, Lion, and Squeezer Creeks in 2007. No evidence of advancing hybridization (e.g., hybrid swarms) was discovered, although it was found that brook trout and brook-bull trout hybrids comprised the majority of the *Salvelinus spp.* biomass in high quality bull trout spawning and rearing habitats. This almost certainly suppresses productivity of the bull trout populations. In 2008, more comprehensive genetic sampling occurred in a number of Swan Lake tributary streams, to establish a more complete genetic baseline. In addition, about 500 fin clips were obtained from sub-adult and adult bull trout in Swan Lake in 2007 and 2008. Pending availability of funding, there are plans to conduct genetic assignment tests on those samples so that the contribution of the tributary populations to the lake can be compared to the observed redd counts and juvenile production.

Reports of lake trout in Swan Lake began in 1998, and have since been confirmed genetically as originating from Flathead Lake. Whether by competition, predation, or some other interaction lake trout have been repeatedly shown to dominate mountain lake ecosystems with native bull trout populations. This portends a bleak prospect for maintaining the currently robust bull trout population in this core area.

The Swan Valley Bull Trout Working Group (SVBTWG) was formed in 2004 to address the apparent illegal introduction of lake trout. There is strong consensus among the SVBTWG that lake trout are an undesirable addition to the Swan Lake ecosystem. Sampling and removal efforts have since confirmed that this is a young and expanding population. The primary focus since 2007 was to gain more information about the population size and structure of the lake trout population in Swan Lake and to identify lake trout spawning locations. Relative weights (Wr); an index of fish condition) of lake trout in Swan Lake are among the highest currently observed throughout the Northern Rocky Mountain region, indicating resources are likely not limiting and lake trout are at relatively low density. Two areas at the southern end of the lake were identified as potential spawning locations, and *in-situ* egg traps buried in the substrate documented spawning.

Whirling disease (WD) was discovered in Swan River tributaries in the late 1990's and bull trout samples from Swan Lake tested positive for the causative organism (*Myxobolus cerebralis*) in four consecutive years (1999-2002; source: National Wild Fish Health Survey database, USFWS). Bull trout are not particularly susceptible to the impacts of whirling disease, based on

laboratory evaluations, but effects on wild fish are not known. In addition, WD was detected in fish from lower Lion Creek. A fish health screening of 60 lake trout taken from Swan Lake in the fall of 2008 detected no reportable pathogens.

Some concern has also been expressed regarding the impacts of a northern pike population established in Swan Lake in the 1980's. However, there appears to be limited niche overlap between pike and bull trout and the bull trout population has remained robust over a 20^{+}-year period with pike present. This is not currently as great a concern as the interactions with lake trout and brook trout.

Considerable habitat data and analysis, beyond the scope of this summary, has been gathered by USFS, Plum Creek Timber, and State Lands (MT DNRC). In 2008 and 2009 a major transfer of Plum Creek lands to the public domain through the Nature Conservancy to DNRC and USFS began. This transfer is expected to benefit bull trout habitat in the long-term, but specific short-term regulatory impacts, involving issues such as the perpetuation of the Plum Creek Habitat Conservation Plan (HCP) obligations (probable on State lands, not on Federal lands) and the potential implementation of INFISH standards (USFS lands) are not yet clear. These positive developments are tempered by ongoing private development in the Swan R drainage. Montana FWP has collected substrate scoring and coring data for a 26-year period on major bull trout spawning and rearing streams indicating, for the most part, that portion of the habitat is stable or improving.

Lands within the Plum Creek Native Fish HCP (and Stimson HCP that spun off from it) occur adjacent to several hundred miles of stream reaches, including substantial holdings that were identified as important bull trout habitat in this core area. Through implementation of the HCP, proactive management is occurring to protect and restore important bull trout habitat, while at the same time allowing the companies to manage and harvest their timber base, construct and maintain roads, and manage other resources such as grazing allotments and recreational properties. An active monitoring strategy is being applied to track compliance and measure important habitat and population parameters. Implementation is being achieved, but it is too soon to assess the overall effectiveness of the program in protecting and restoring bull trout and their habitat.

The Montana DNRC is developing an HCP, and a take permit is expected to be issued in late 2010. The permit covers 548,500 acres of State School Trust lands and includes forest management related activities (including roads) and livestock grazing. Focal species include bull trout, westslope cutthroat trout, and native redband trout. A relatively large amount of state trust lands are present in the lower portions of the Swan watershed, including the Swan River State Forest.

Swan Lake is the only water body in Montana where angler harvest of bull trout has been permitted since 1998, with a sustained annual harvest of approximately 500 fish per year. The Swan Lake bull trout fishery has remained open to angler harvest, despite the concerns about impacts of lake trout in the drainage, largely because spawning runs have remained stable and there is no evidence anglers are impacting adult abundance. There is a planned creel survey on the lake for 2009, which will provide the first quantitative information on this fishery since 1995. The intensive lake trout targeted gill netting has generated concerns that incidental mortality of

bull trout in the bycatch may depress the population. To date, the combined effects of angling harvest and the lake trout removal effort do not appear to be causing overutilization of bull trout, but will continue to be closely monitored.

A key modifier of lake trout and bull trout interaction may be the roles played by *Mysis* shrimp and kokanee, introduced species in Swan Lake and in relatively high abundance. Additional monitoring of these species will be important in providing further information regarding the trophic status of the ecosystem, and further understanding of the non-native species and their relationships with bull trout.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Introduced species/fisheries management** (including *Mysis* shrimp)
- **#2 Forest management practices and forest roads**
- **#3 Angling or harvest** (legal or illegal).

Other activities, currently ranking lower in importance include:

- **Residential development and urbanization**
- **Water quality impairment from non-specific or multiple sources**.

The status of bull trout in this core area was considered "stable" and trend was "increasing" based on information available at the time of listing. The current status of the species in this core area is amongst the strongest in the entire range, though numerically redd counts are down about 30% since the peak recorded in 1998, so the trend is no longer considered increasing. If lake trout expansion (perhaps exacerbated by the undetermined effects of whirling disease) cannot be halted or mitigated, it is expected that bull trout abundance in this core area will experience steep declines within the next 10-25 years. Currently, FWP is addressing this threat, although even with adequate funding and resources the outcome is far from certain. Potential long-term benefits accruing from implementation of three HCP will largely protect the habitat status quo, but will not be adequate to offset negative effects of lake trout introduction and continuing impacts from other established introduced species (*Mysis*, brook trout and northern pike). These non-native species concerns, especially lake trout and brook trout, affect the entire Swan Lake core area and extend to upstream (Holland and Lindbergh Lakes) and downstream (Flathead Lake) core areas.

In other drainages within the Flathead River basin lake trout invasion or introduction has resulted in the collapse of bull trout populations within a brief 25-30 year period. In ecosystems with established food chains that can support high rates of lake trout expansion and survival, particularly those such as Swan Lake where *Mysis* and kokanee are present, resulting collapse of bull trout has been profound and (to date) irreversible.

Strong emphasis has been placed on protection of habitat in important spawning and rearing streams on both public and private lands. However, some of those gains will be offset by the increasing pace of development on private lands on the valley bottom. Bull trout have shown the ability to maintain a relatively high population level in the Swan Lake core area despite past impacts from land management (development, highways and forest management), angling harvest, and non-native species introductions. This is attributed in large measure to the relatively

abundant and high quality ground water-influenced tributary spawning and rearing habitat. The future viability of bull trout in the Swan Lake core area depends ultimately on the outcome of lake trout suppression efforts. Lake trout expansion over the past 10 years has not resulted in measurable impacts to the bull trout population. If the lake trout population can be dramatically reduced in the near term, it may be possible to maintain the threat as low or at worst moderate severity. If the lake trout suppression effort fails, it is anticipated that within one to two bull trout generations (five to ten years) the impact to bull trout will be severe and the threat would then be considered high in severity, and lead to irreversible declines in the bull trout population.

An abundance of cold, ground water-fed spawning and rearing streams occur in this core area and are unlikely to be impacted by climate change. Second tier spawning streams would be the least resilient. A bigger concern may be that Swan Lake is relatively shallow (140-foot maximum depth) and already has a documented oxygen sag in a portion of the basin, so the amount of cold-water lacustrine habitat could decline with increasing summer water temperatures.

Holland Lake – 170102110103

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area.

Spawning and rearing habitat is limited to a short reach (400 m) of stream in the lake inlet below Holland Falls. Holland Cr provides very limited habitat for juvenile bull trout and it is likely many out-migrate as fry, with unknown survival.

Redd monitoring has occurred annually since 1991, and counts have ranged from five to19, averaging about 11. This is the only spawning stream in the core area and redds in this stream are easily recognized, typically quite large, providing a high degree of confidence in the accuracy of this index. Based on these observations, the number of adult bull trout in the Holland Lake core area is 50-100 fish. For a small system with low numbers of adult fish, these numbers are remarkably stable. However, there is concern over the expanding lake trout population in Swan Lake and potential effects if lake trout disperse upstream into Holland Lake. Regardless, this core area is functioning below historical levels of natural abundance and is approaching a threshold of concern.

The core area is well connected with Swan Lake downstream and Lindbergh Lake in the adjacent watershed. The Swan Valley Bull Trout Working Group (SVBTWG) has expressed concern about the vulnerability of Holland and Lindbergh Lakes to lake trout invasion. In 2008, a lake trout PIT-tagged in Swan Lake in 2007 was caught by hook and line at the confluence of Holland Creek and the Swan River. These core areas each host small, but important bull trout populations. There is no physical barrier to prevent Swan Lake fish from dispersing upstream and colonizing either lake. Based on high cost estimates and lingering uncertainty whether lake trout have already invaded the lakes, SVBTWG has not pursued installing a barrier on the outlet of Holland Lake. Additional concerns were raised over ecological effects a fish barrier would have on other migratory fish species within the drainage. In addition, beginning in 2008, the short reach of bull trout spawning and rearing habitat in Holland Creek, upstream of Holland Lake, was closed to all fishing.

There is no new quantitative information, but the Holland Lake bull trout population is small, and subject to incidental mortality and illegal harvest. A key modifier of lake trout and bull trout interaction may be the roles played by *Mysis* and kokanee, two introduced species currently present in Holland Lake, but of unknown abundance. Additional monitoring of these species will be important in providing further information regarding the trophic status of the lake, and further understanding of non-native species effects on bull trout.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Angling or harvest** (legal or illegal)
- **#2 Forest management practices and forest roads**
- **#3 Residential development and urbanization**.

While these are the three primary existing threats, the near proximity and potential for lake trout invasion is considered to be the greatest future threat, perhaps dwarfing the combined existing threats.

The status of bull trout in this core area was considered "depressed" and trend was "unknown" based on information available at the time of listing. Bull trout have shown the ability to maintain a relatively stable but low population level in Holland Lake despite the limited spawning and rearing habitat, and past impacts from land management (lakeshore development and forest management), angling harvest, and non-native species introductions (*Mysis*, kokanee, brook trout). The future viability of bull trout in the core area depends on the ability to keep lake trout out of this system. Since no active methods to preclude colonization are available, lake trout expansion from Swan Lake into Holland Lake is highly possible, if not probable. If lake trout colonization of Holland Lake occurs, it is anticipated that within one to two generations (five to 10 years) the impact to bull trout will be severe, probably leading to irreversible declines and functional extinction of the population, if not outright extirpation.

The limited spawning and rearing habitat is on National Forest land and relatively secure. Potential long-term benefits accruing from implementation of three Habitat Conservation Plans (see Swan Lake core area above) are expected to effectively maintain the habitat status quo downstream of Holland Lake, but would not be adequate to offset invasion by lake trout and complicating factors from established brook trout populations.

There is no evidence that incidental bycatch of bull trout in the lake and/or illegal harvest is negatively impacting the bull trout population. Limited bull trout spawning and rearing habitat occurs in this core area, perhaps making it slightly more likely to be affected by climate change than larger, more connected systems like Swan Lake. A bigger concern may be that Holland Lake is relatively small (approximately 408 acres) and shallow (approximately 156-foot maximum depth) and the amount of cold-water lacustrine habitat could decline with increasing summer water temperatures.

Lindbergh Lake – 170102110102

By definition, fish originating from a lake-dwelling population are adfluvial and migratory; there is no evidence of resident fish in this core area.

Redd monitoring has been conducted three times in the upper Swan River and Crystal Creek, with 26 redds in 1994, 9 redds in 1997, and 16 redds in 2001. These data suggest the adult bull trout population in the Lindbergh Lake core area is fewer than 100 fish, with no trend detectable at this time. It is not known whether this population is functioning at historical levels of abundance, but numbers are low given the size of the lake (725 acres) and relatively high quality of habitat in the watershed. No additional information has been collected since 2001, and there is concern over the expanding lake trout population in Swan Lake.

Access to the upper watershed is restricted by a natural barrier falls. The core area is well connected with Swan and Holland Lakes, downstream. Unfortunately, this connectivity also presents a risk of invasive species (lake trout, Mysis, kokanee, and northern pike). An unverified report by a reliable angler of the catch of a lake trout from Lindbergh Lake occurred in 2004, and in 2008 a lake trout PIT-tagged in Swan Lake in 2007 was caught by hook and line at the confluence of Holland Creek and the Swan River. No suitable locations for barriers to isolate this core area have been identified in the Swan River downstream of Lindbergh Lake.

The Swan Valley Bull Trout Working Group (SVBTWG) has expressed concern given the vulnerability of Holland and Lindbergh Lakes to lake trout invasion. These core areas each host small, but important bull trout populations. There is no physical barrier to prevent Swan Lake fish from dispersing upstream and colonizing either lake. Based on high cost estimates and lingering uncertainty whether lake trout have already invaded the lakes, the SVBTWG identified no barrier location for Lindbergh Lake. Additional concerns were raised over ecological effects a fish barrier would have on other migratory fish species within the drainage.

See Swan Lake summary above for a discussion regarding the land exchange and Habitat Conservation Plans in the Swan River drainage. Also, while non-native *Mysis* and kokanee are not known to be present in Lindbergh Lake, both have become established in nearby Holland Lake.

Management activities or outcomes that induce limiting factors and currently represent the greatest threats to bull trout in this core area include:

- **#1 Angling or harvest** (legal or illegal)
- **#2 Forest management practices and forest roads**.

While these are the three primary existing threats, the near proximity and potential for lake trout invasion is considered to be the greatest future threat, perhaps dwarfing the combined existing threats.

The status of bull trout in this core area was considered “depressed” and trend was “unknown” based on information available at the time of listing; the current status and trend of bull trout in this core remains undocumented. The limited survey history indicates an adult population of bull trout of fewer than 100 fish. A rather small population of adfluvial bull trout in this core area has persisted, but remains vulnerable. Relatively little is known about the species complex and species interactions in the lake and stream system. Bull trout have shown the ability to maintain themselves despite a relatively unknown but presumed low population level in the Lindbergh Lake core area, despite limited spawning and rearing habitat and past impacts from land management (lakeshore development and forest management), angling harvest, and non-native

species introductions (*Mysis*, brook trout). The viability of bull trout in the Lindbergh Lake core area ultimately depends on the ability to keep lake trout out of this system. Since no active methods to preclude colonization are available, lake trout expansion from Swan Lake into Lindbergh Lake is highly possible, if not probable. If lake trout colonization of Lindbergh Lake occurs, it is anticipated that within one to two generations (five to10 years) the impact to bull trout will be severe, probably leading to irreversible declines and functional extinction of the population, if not outright extirpation.

The limited habitat in the spawning and rearing stream is on mixed private and National Forest land and is relatively secure. However, development of recreational property is continuing in the drainage. Long-term benefits that are expected to accrue from implementation of three HCP, including the transfer of Plum Creek lands into Forest ownership as a result of land acquisition, are expected to maintain the habitat status quo, but would not be adequate to offset invasion by lake trout and complicating factors from established brook trout populations. Also, there is no evidence that incidental bycatch of bull trout in the lake and/or illegal harvest is negatively impacting the bull trout population.

Adequate cold, ground water-fed bull trout spawning and rearing habitat occurs in this core area, perhaps making it less likely to be impacted by climate change than nearby Holland Lake. A greater concern may be that Lindbergh Lake is relatively shallow (approximately 125-foot maximum depth) and the amount of cold-water lacustrine habitat could decline with increasing summer water temperatures.